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PERMIAN BRACHIOPODA AND BIVALVIA FROM SAHUL SHOALS NO. 1, ASHMORE BLOCK, NORTHWESTERN AUSTRALIA

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Abstract: The brachiopod and bivalve fauna of the Permian limestone of the Sahul Shoals No. 1 bore core, northwestern Australia is described and the following forms recognised: streptorhynchid fragments, strophalosiid? indet., *Waagenoconcha* sp., *Neospirifer* sp., *Eliva*? sp., *Gjelispinifera* sp., terebratulid indet., *Etheripecten*? sp. and *Cyrtorostra* sp. The fauna is interpreted as indicating the palaeogeographical proximity of the sites of deposition of the Sahul Shoals Late Permian limestone and the Late Permian limestones of the Maubisse Formation of Timor.

Sahul Shoals No. 1 well was drilled in late 1969 and early 1970 by Burmah Oil Company of Australia Limited (BOCAL). The well is located (Fig. 1) at the western end of the offshore Bonaparte Basin (11°25′36″S, 124°32′50″E), 375 km northwest of Cape Londonderry, Western Australia and 137 km south of Timor, Indonesia (Jones & Nicoll 1985). The well is situated on the northeastern end of the Ashmore Block (Laws & Kraus 1974, fig. 4, p. 78), close to where this structure is truncated by the Timor Trough (Kraus & Parker 1979).

Sited in 28 m of water, the well was drilled to a total depth of 3802 m (Jones & Nicoll 1985). The original well completion report has not been published but subsequent investigations on portions of the core (Skwarko & Kummel 1974, Jones & Nicoll 1985, Helby *et al.* 1987) have refined correlations for the Triassic sections of the core. Little has been published on the bottom 53 m of the core which consists of recrystallised Permian limestone (Jones & Nicoll 1985).

PERMIAN INTERVAL

The original determination of a Late Permian age for the light-coloured limestone was made by K. S. W. Campbell, in the unpublished BOCAL report, on the basis of Bryozoa and Brachiopoda present in the core. Campbell's age determination was published by Runnegar (1977, p. 5, 1979, p. 146) while noting a personal communication from Campbell that the limestone "contains incomplete specimens of *Neospirifer* of the type found in Basleo, Timor". The existence of Permian limestone from Sahul Shoals No. 1 had previously been mentioned by Skwarko and Kummel (1974) and Laws and Kraus (1974), the latter also indicating that the sediments were Upper Permian in age. Veevers (1984, p. 114) also repeated Campbell's Late Permian age determination.

MATERIAL

The limestone is a fine-grained, light-grey, recrystallised biomicrite with patches of creamy-white, coarse, sparry calcite (crystals up to 0.75 cm long). Some of the sparry calcite is related to crinoid debris. Secondary calcite veins and stylolites are common. Macrofossils are invariably incomplete and difficult to prepare. Nevertheless, even small fragments may preserve details of surface ornament and hence can be referred with confidence to a particular family. Other specimens can be identified down to the generic level and hence compared in general terms with known species.

All figured specimens are housed in the Commonwealth Palaeontological Collections (CPC) of the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T.

PALAEOGEOGRAPHY

The presence of Late Permian limestone on the outer edge of the northwestern shelf of the Australian continent, relatively close to Timor, has been mentioned in several investigations concerned with the relationship during Permian times of the Permian Maubisse limestones of Timor with Permian sedimentation of northwestern Australia (e.g., Hamilton 1979, Runnegar 1984, Veevers 1984). The tectonic relationship of Timor to Australia, including the "indubitably autochthonous terrain" of the Sahul Shelf (Veevers 1984, p. 113) is complex and three broad models have been proposed to explain the relationship (see Barber 1981, Berry *et al.* 1984, Veevers 1984; p. 113 for summaries). Much argument has centred on whether the Permian Maubisse Formation, which has yielded most of the rich brachiopod faunas of Timor, was allochthonous or autochthonous at the time of deposition to the Australian continental margin (Crostella 1977, Chamalaun & Grady 1978, Audley-Charles 1983).

Critical to the above debate is the detailed reexamination and biostratigraphical analysis of pertinent Permian faunas from Timor and northwestern Australia. As a result, this study describes and figures the available material from Sahul Shoals No. 1 and concludes that the brachiopods and bivalves strongly indicate a close relationship between the Sahul Shoals fauna and the faunas of the Basleo age localities of Timor and the Hardman Formation (Canning Basin)

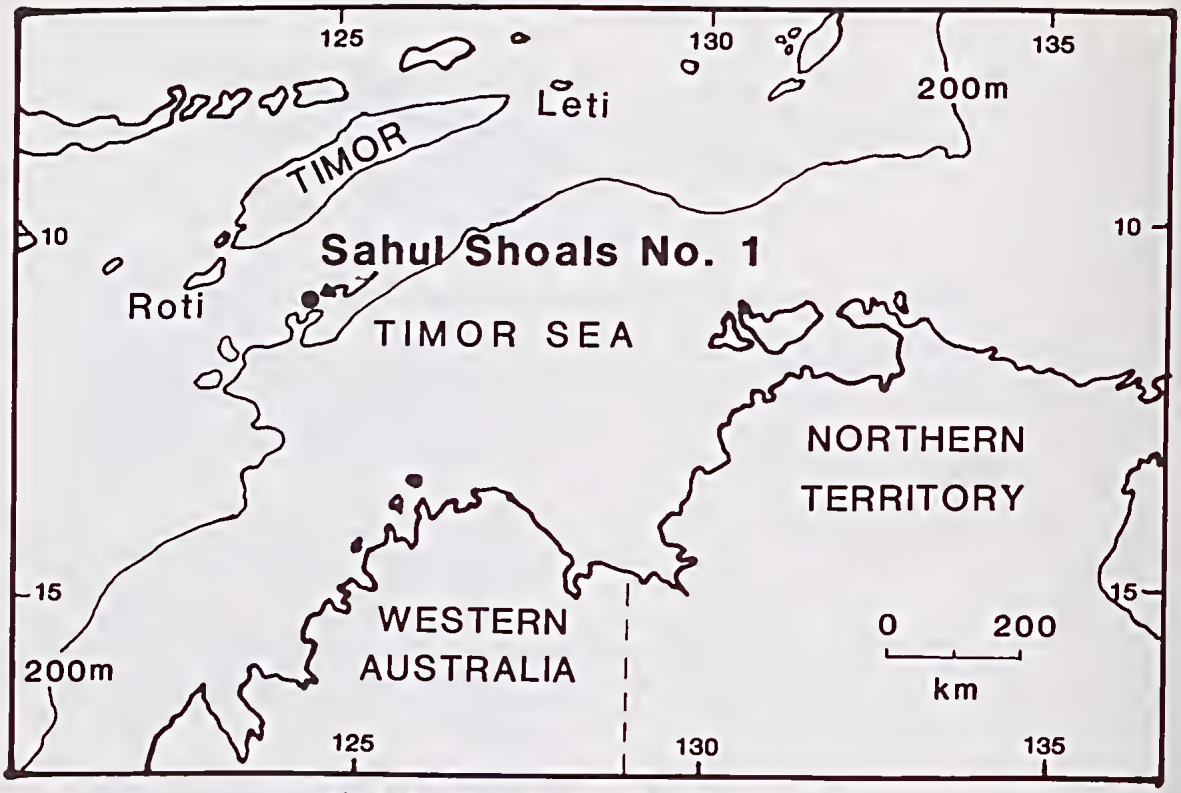

Fig. 1—Location diagram of Sahul Shoals No. 1.

and Upper Marine Beds of the Port Keats Group (Bonaparte Gulf Basin), northwest Australia. All these faunas, including the present Sahul Shoals fauna, are considered to be "Chhidruan" (i.e. immediately post Kazanian) in age (e.g. see Archbold & Thomas 1986a) and hence supports the original age determination by Campbell. The close relationship of the Sahul Shoals fauna with those of Basleo and correlative localities in the Maubisse Limestones of Timor indicates ease of interchange and migration between the two regions. The similarity of faunas is interpreted as reflecting the palaeogeographical proximity of the two depositional areas during the Late Permian.

IDENTIFICATIONS AND DISCUSSION

Table 1 provides details of the available core samples and the identifications determined. Identifications are discussed below under the headings Brachiopoda and Bivalvia. The material is not adequate for full formal descriptions.

Brachiopoda

Streptorhynchid indet. (Fig. 2A-B)

Two fragments indicate the presence of the family Streptorhynchidae in the fauna. Costae increase by intercalation and rarely by bifurcation. Widely-spaced, major growth stages occur on both fragments. The larger fragment (with coarser costae) indicates a large shell (over 3 cm in width). Costae on the smaller fragment (submature or juvenile shell?) number about 6 per 2 mm; on the larger fragment costae number between 2 and 4 per 2 mm.

Although the fragments are inadequate for detailed comparison with described species, it can be noted that large streptorhynchids occur in correlative faunas at Basleo, Timor (Brolli 1916) and in northwestern Australia (Archbold 1988).

Strophalosiid? indet. (Fig. 2C)

A small fragment of a strongly-convex valve with distinct spine bases appears to indicate the presence

Fig. 2—A, streptorhynchid fragment, CPC 19853, x 1.4. B, streptorhynchid fragment, CPC 19857, x 1.4. C, strophalosiid? latex cast of fragment of ventral valve, CPC 19893, x 1.5. D-G, *Waagenoconcha* sp., ventral valve in ventral, lateral, posteroventral and ventral views, CPC 19891, x 1.5 and x 2. H, *Waagenoconcha* sp., latex cast of portion of ventral valve, CPC 19892, x 1.5. I, *Neospirifer* sp., portion of shell, CPC 19858, x 1.5. J, *Neospirifer* sp., latex cast of portion of shell, CPC 19859, x 1.3. K, *Neospirifer* sp., portion of ventral valve, CPC 19852, x 1. L, M, *Neospirifer* sp., incomplete dorsal valve in dorsal and antero-dorsal views, CPC 19856, x 1. N, O, *Neospirifer* sp., external mould of portion of shell and latex cast, CPC 19890, x 1 and x 1.25. P, Q, *Eliva*? sp., incomplete ventral valve in ventral and postero-ventral views, CPC 19861, x 1.5. R, S, *Gjelispinifera* sp., dorsal valve and latex external mould, CPC 19855, x 1.2 and x 1.6. T, U, terebratulid indet., ventral valve in ventral and antero-ventral views, CPC 19860, x 1.3. V, *Cyrtorostra* sp., incomplete valve, CPC 19854, x 2. W, *Etheripecten*? sp., fragment of valve, CPC 19862, x 1.4.

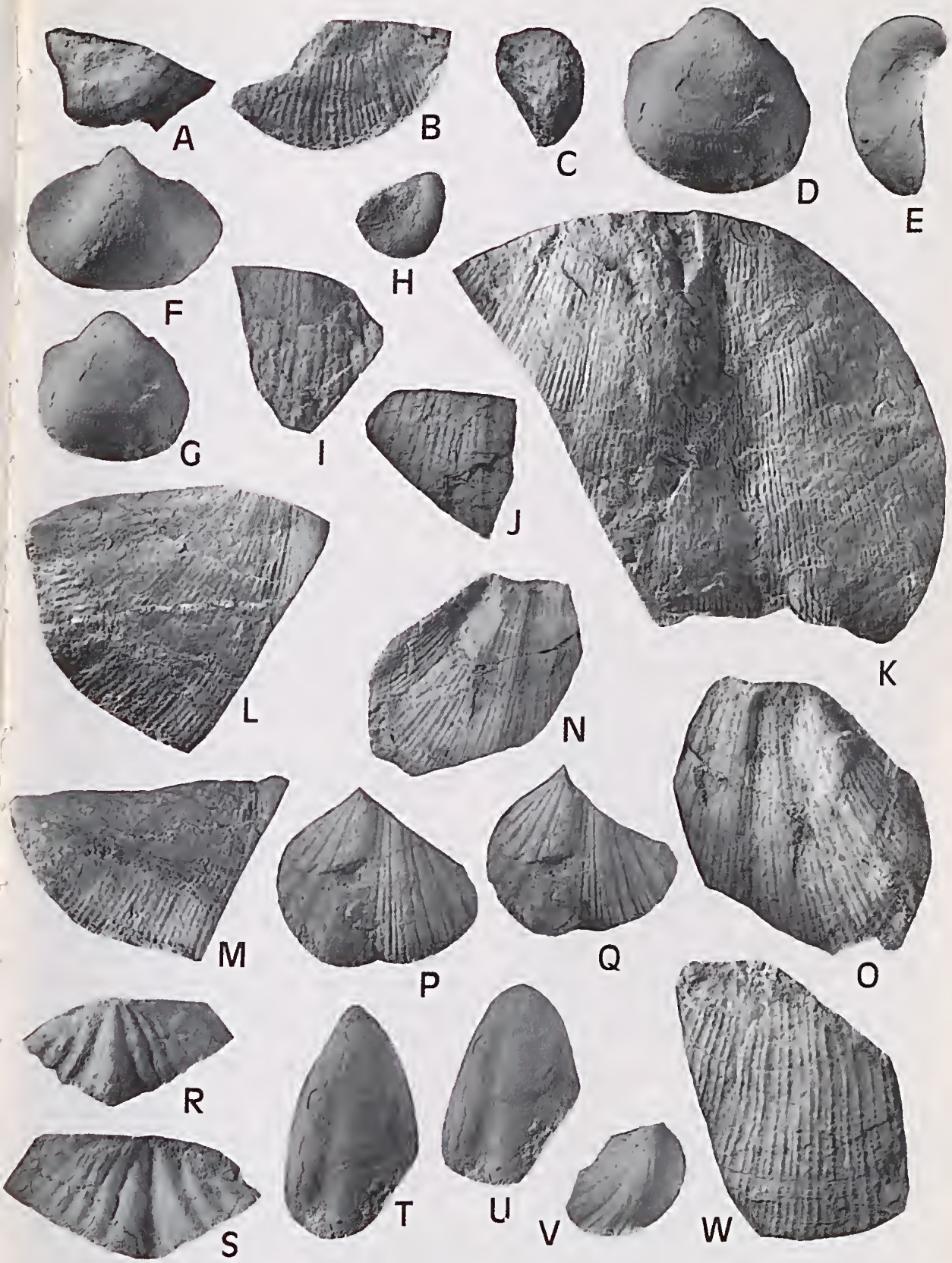
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TABLE 1
SAMPLE DEPTH AND IDENTIFICATIONS.

Sample Depth (metres)	Identification	Specimen Number
3797.81	*Neospirifer* sp.	CPC 19852
	strophalosiid? fragment	CPC 19893
3797.88	streptorhynchid fragment	CPC 19853
	Cyrtorostra sp.	CPC 19854
3797.96	*Gjelispinifera* sp.	CPC 19855
3798.49	*Neospirifer* sp.	CPC 19856
3798.65	streptorhynchid fragment	CPC 19857
	Neospirifer fragments (2)	CPC 19858-19859
3798.72	plicate terebratulid	CPC 19860
	Eliva? sp.	CPC 19861
3798.87	*Etheripecten*? sp.	CPC 19862
3799.03	*Neospirifer* sp.	CPC 19890
	Waagenoconcha sp.	CPC 19891
3799.13	*Waagenoconcha* fragment	CPC 19892

of a small strophalosiid in the fauna. The specimen is inadequate for detailed comparison with known species but it can be noted that small strophalosiids are known from the late Permian faunas of Timor (Broili 1916) and northwestern Australia (Archbold 1988).

Waagenoconcha Chao, 1927

Waagenoconcha *sp.* (Fig. 2D-H)

A small, immature, ventral valve and a small fragment of an external mould of an immature ventral valve indicate the presence of *Waagenoconcha*. Although decorticated, traces of spine bases in a subquincunxial pattern are visible as are widely-spaced, concentric, growth stages on the complete ventral valve. Spine bases are fine (2 to 3 per 1 mm at 0.5 cm from umbo; 1.5 to 2 per 1 mm at 1.2 cm from umbo). No ventral sulcus is indicated although by the anterior of the ventral valve (1.5 cm from umbo) a median flattening of the valve is developed.

Large *Waagenoconcha* is a feature of Basleo faunas of Timor (Archbold & Bird in press) and Chhidruan faunas of northwestern Australia (Archbold 1988). The fine spine bases indicate a slightly closer relationship to the northwestern Australian species (Archbold & Bird in press). Fine spine bases are a common feature of Late Permian species of *Waagenoconcha* (e.g., see Tazawa 1974).

Neospirifer Fredericks, 1924

Neospirifer *sp.* (Fig. 2I-O)

Neospirifer is well represented in Sahul Shoals No. 1. Fragments vary in size but a large species is indicated with low lateral plications, fine ribs, a broad ventral sulcus and a distinct dorsal fastigium.

Large *Neospirifer* species with the above general characters are characteristic of the Chhidruan faunas of Timor (Broili 1916, Archbold & Bird in press) and northwestern Australia (Archbold & Thomas 1986b).

Eliva Fredericks, 1924

Eliva? *sp.* (Fig. 2P-Q)

An incomplete, apparently elongate, non-thickened spiriferid ventral valve indicates the presence of *Eliva* or an allied genus in the fauna. The genus *Eliva* has been interpreted by Archbold & Bird (in press) to include a species from Maubisse Formation outcrops near Kasliu Village, West Timor. The Timor species, from a fauna correlated with the Basleo locality, is more elongate than the present specimen but exhibits weakly-developed fasciculation of fine costae similar to that of the specimen from Sahul Shoals. No comparable form is known from northwestern Australia.

Gjelispinifera Ivanova, 1975

Gjelispinifera *sp.* (Fig. 2R-S)

1916 *Spiriferina cristata* sensu Broili, p. 47, pl. 9, figs 2-6.

non 1816 *Terebratulites cristatus* von Schlotheim, p. 28, pl. 1, figs 3a-3c.

A decorticated, transverse, dorsal valve demonstrates the presence of a spiriferinid in the Sahul Shoals fauna. Five or possible six lateral plicae are present on the valve flanks and the prominent fastigium carries a low subsidiary plication on each flank. External micro-ornament is not preserved and punctae are poorly preserved in the shell structure.

The relatively large size of the specimen and the number of lateral plicae suggest a close comparison with the *Spiriferina cristata* of Broili (1916, especially pl. 9, fig. 3). Broili's species is large and some specimens possess subsidiary plicae on the flanks of the fastigium. Broili's species requires renaming and assigning to *Gjelispinifera*, as indicated by Ivanova (1975); it is not close to Schlotheim's (1816) species, the type species of *Spiriferellina* Fredericks (1924). Examples of Broili's species, collected by Dr P. Bird from Basleo, Timor, confirm the generic assignment to *Gjelispinifera*.

No comparable species to the specimen from Sahul Shoals are known from the onshore Late Permian faunas of northwestern Australia.

Terebratulid indet. (Fig. 2T-U)

An elongate, trigonal ventral valve with an anteriorly-developed, broad, shallow sulcus, which in turn carries a broad, low, median fold suggests the presence of *Hoskingia* (Campbell 1965) or a related genus. Species of *Hoskingia* are common in the Late Early Permian faunas of Western Australia and they can be of relatively small size (e.g. Campbell 1965, pl. 10, fig. 1). The Late Permian northwestern Australian species of the genus is huge (Campbell 1965) and hence is not close to the present specimen.

Hoskingia is not known with certainty from Timor although the *Dielasma biplex* of Hamlet (1928, pl. 10, fig. 10) from Nefotassi, is a small shell comparable in size with the present specimen; it is, however, less trigonal in outline. Judging from the species list for Nefotassi (Hamlet 1928, pp. 110-113), the locality is a correlative of Basleo.

BIVALVIA

Etheripecten Waterhouse, 1963

Etheripecten? *sp.* (Fig. 2W)

A single fragment of an apparently large, gently-convex valve probably represents a piece of a large bivalve shell. Costae are narrow, sharp, simple and increase by intercalation and are separated by broad, flat-based interspaces. Concentric growth lines form a small pustule where costae are crossed. The micro-ornament is of fine radial capillae. Growth lines arch centrally over the costae.

Etheripecten is abundant in the Permian faunas of Western and eastern Australia and New Zealand (Archbold & Skwarko 1988). The genus has not been formally described from Timor although *Aviculopecten* sp. from Noil Boenoe (Hamlet 1928, pl. 12, fig. 12) may indicate the presence of the genus.

Cyrtorostra Branson, 1930

Cyrtorostra *sp.* (Fig. 2V)

Portion of a right valve indicates the presence of *Cyrtorostra*. Costae are sharp and strong with strong secondaries arising in the interspaces. *Cyrtorostra* is present in Timor (Branson 1948) in the form of the *Oxytoma atavum* of Hamlet (1928, pl. 12, figs 1-3), a form with somewhat similar, sharp costae overlaying broad plicae. The Timor species is from Fateo Koeat, a locality correlated with Basleo.

As yet, *Cyrtorostra* is not known from the Late Permian of Western Australia.

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